VIII.—*On the difference of level in Indian Coal fields, and the causes to which this may be ascribed. By* J. McClelland *Esq. Secretary to the Committee for investigating the Coal and Mineral resources of India.*

[Extracted with permission from the Committee's Reports now under publication.]

Before proceeding to notice the information which has been published or reported to government regarding the various coal fields, it will be desirable to offer a few observations on the geological features of that portion of India in which they occur, more especially beyond the Ganges.

The face of the country rises gradually as we cross the plains on the western side of the *Hoogley* towards the range of hills, at the base of which the coal field of *Burdwan* is situated; this is proved by the following fact noticed by the late Mr. Jones, namely, that at *Omptah,* twenty-two miles due west of *Calcutta,* and the same distance from the sea as that city, the tides in the *Damuda* derived from the estuary of the *Hoogley* rise but ten inches during the springs of June, ebbing and flowing only half an hour*. In *Calcutta* on the other hand there is a difference of seventeen feet between high and low water during the same springs†, from which we may perhaps infer, that the plain in this direction ascends nine inches per mile for the distance of twenty-two miles from the *Hoogley;* beyond this, the surface is known to rise more rapidly throughout the extent of sixty or seventy miles to the foot of the hills, which is the cause of those violent floods that render the navigation of the *Damuda* so difficult‡.

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* We should think the facts here noted prove rather the two places to be on the same level. As far as the tide reaches, the average of high and low water will be very nearly the level of the sea, unless there is a considerable flow of water from above, which is less the case in the *Damuda* than in the *Hoogley.* The lift depends on the body of water, depth, and configuration of the channel, and the *Damuda* only gets an offset from the *Hoogley* tidal supply. The height of the surface of the land may be safely measured from the average of high and low water mark. See a paper on this subject by Captain T. Prinsep, Gl. Sci. Vol. II.—Ed.

† See Kyd's Tables, Asiatic Res. 1829.

‡ Mr. Jones states that the *Damuda* river is open from the middle of June to the end of September for boats of 300 maunds burden, from *Omptah* to the situation at which the coal is raised, and that each boat is capable during this period of passing five times between these situations. It is necessary, when from a slight cessation of rain the river is perceived to fall, to haul the boat on the highest practicable ground, and there await the succeeding flood, which sets in with so much impetuosity as to overwhelm whatever may happen to be in its course.

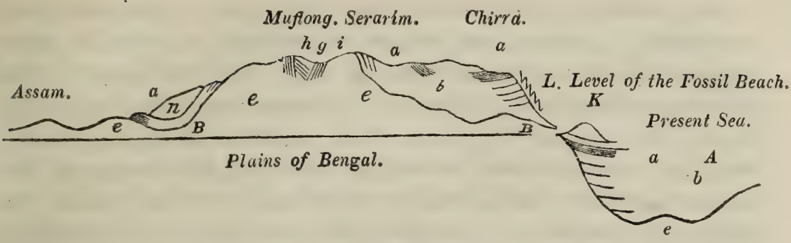
On the eastern side of *Calcutta* on the contrary, there is a depression, though probably of less amount, extending gradually to that portion of the *Sunderbunds* marked 'morass,' in ARROWSMITH's map, a little on the west of *Culna*. This lowest situation perhaps of the *Sunderbunds*, is situated midway between the *Tiperah* hills on the east, and those hills the continuation of which on the western side of the *Hoogley*, contains the *Burdwan* coal field; the distance across the alluvium on either side being about 150 miles, making the breadth of the united delta of the *Ganges* and *Brahmaputra*, at this situation 300 miles.

If from the morass, we proceed two and a half degrees due north, we find the breadth of the great delta contracted between the *Garrow* and *Rajmahl hills* to 150 miles, from which situation the alluvium again expands into the plains of its respective rivers, extending northwest and north-east respectively, and leaving an obtuse angle formed by the *Sikkim* and *Bhotan* mountains, pointing toward the great delta, and forming with the *Rajmahl* and *Garrow* mountains three points of a nearly equilateral triangle, which constitutes the nearest local connexion of the three distinct systems of Indian mountains; and at each of the three situations, viz. *Rajmahl*, *Chilmary*, and the *Teesa* river coal has been found.

It would be hazardous to draw any conclusion from this interesting fact, until we are better acquainted with the nature and relative position of the strata in each locality. Should the coal of the three situations prove to be the same formation, borings in that case conducted in various intermediate points in *Purnea* and *Dinagepore*, might detect the coal measures buried beneath this portion of the delta; (vide a. A. Fig. 1) but at present our data are too vague to justify the expense of such a mode of inquiry in this quarter. It would rather seem that the intervening coal measures were upheaved with those of the adjacent mountains, and subsequently overthrown by the *Ganges* and *Brahmaputra*, or by other causes hereafter to be considered.

Although we have at *Chirra Punji*, a bed of coal raised on an insulated summit 4300 feet above the level of the sea, the rocks by which it is accompanied are identical in their nature with those that are found bearing a similar relative position to other beds of coal of the same formation, whether above or below the level of the sea. The annexed figure will render these observations better understood.

a a a a a Coal. *b b* Great sandstone forming the base of the coal measures.
e e e e Igneous rocks. *g* Basaltic quartzose-rocks, reposing on the greenstone (*i.*)
i Greenstone. *h* Granular slaty quartz, or metamorphosed sandstone.
k Nummulite limestone. *m* Slate clay.
n New sandstone, containing in the south side of Assam fragments of coal and fossil trees.



The section of the *Kásya* mountains here represented is not ideal, although the horizontal distances are contracted for convenience.

With regard to the tertiary beach *L*, it is a settled point in such cases that it is the land and not the sea that has undergone an alteration of level. The difference between the fossil beach and the present sea, is consequently the quantity which these mountains have increased in height since the tertiary period, indicated by the character of the shells of which the fossil beach is constituted, thus accounting at once for the principal difference of level between the coal at *Chirra* and that of *Burdwan* on the opposite side of the delta. The bursting of a submarine volcano between the points *B*, *B*, from beneath a secondary basin A, composed of the coal measures, would necessarily if on a scale of sufficient magnitude uplift the intermediate portion of the latter, separating the strata *l*, *l*, *l*, *l*, which were continuous before the elevatory movements commenced. This will also account for the presence of coal at the base, as well as on the summit of the mountain at *Chirra**. The great mass of igneous rocks *e*, *e*, *e*, *e*, which appear to have been chiefly instrumental in effecting the upheavement of the coal measures, is sienite; but at *i*, situated on the southern side of the *Bogapany* river, greenstone is seen protruding from beneath the lower strata of sandstone here represented by a coarse conglomerate of boulders, imbedded in some occasions in a matrix of felspar, as in the valley of the *Calapany**. The greenstone *i*, forms the whole declivity on the south side of the *Bogapany*, down to the bed of the torrent which is formed of a glassy basalt, apparently nothing more than altered masses of that portion of the sandstone formation which has been here entirely overthrown by the causes just adverted to†. Ascending from the torrent along the precipitous face of the mountain to *Muflong*, the metamorphosed rock gradually loses its columnar structure, and assumes the character of granular slaty quartz. In the vicinity of *Muflong*, this last form of rock, which may be traced by several gradations into ordinary sandstone, rests on sienite in highly inclined masses. Sienite forms some of the loftiest summits in this situation, but appears to pass, on declivities, into a rock formed chiefly of felspar in a fine granular crystalline state, with a little quartz‡; and enclosing granitic masses which undergo concentric decay, and occasionally beds of mica, and sometimes of quartz much comminuted. This constitutes the principal formation over which the road extends from *Mairang* into the valley of *Assam*. Somewhere on either side of the lower portion of this declivity, coal measures have been detected the same as on the *Bengal* face of the mountains, but accompanied with newer sandstones containing salt springs in addition to fossil trees and detached fragments of coal. Limestone, agreeing in mineral characters and probably in fossil contents with that of *Chirra*, also occurs in this side of the mountains; but the relative position of the beds, as well as all other important geological features here remain unexplored§.

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* The existence of a sub-marine basin of a depth which according to these views must have been equal to the entire height of the mountains, may appear to be incompatible with the depth to be assigned to the sea which would appear to have covered Bengal during the tertiary period. The existence of an unfathomable abyss called the swatch of no ground, close to the mouths of the Ganges, and surrounded by shoal water where the deposit of silt might be supposed rapidly to remove such a remarkable feature, leaves little difficulty in conceiving the great depth to which marine valleys may descend. The swatch is about 5 miles east of *Lacom's Channel:* it is fifty miles long, and thirty broad, and within a mile or two of sands which are left bare at low water; 130 fathoms of line have been tried without effect, and this, within so inconsiderable a distance from the northern side of the swatch, where soundings indicate only 7 fathoms, as to leave little doubt of this sub-marine valley presenting as precipitous declivities as we are in the habit of witnessing from the loftiest table-lands. For the soundings of this basin see Horsburgh's Map of the Bay of Bengal.

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* This is a small but precipitous river valley, met with in the table-land between the *Serarim* and the *Bogapany*.

† It is always satisfactory on such occasions to find the views of different observers agree in ever so limited a degree: I may therefore remark that Sir EDWARD RYAN and Mr. CRACROFT, who on distinct occasions crossed this portion of the *Kásya* mountains prior to the visit of the Assam deputation, also found rocks which they denominated basaltic. No 21 in Sir EDWARD's collection of specimens presented to the Asiatic Society's museum is named 'basaltic quartz' from the bed of the *Bogapany;* and is the same as the glassy basalt abovementioned. Mr. CRACROFT's collection of specimens from between *Muflong* and *Serarim* also contains a 'basalt' as well as 'a coarse quartzy sandstone'—(Vide Journal of the Asiatic Soc. Vol. III. 296) which is the metamorphosed sandstone here spoken of.

‡ Described in my geological catalogue as primary sandstone.

§ Figs. 25, 20, 21, and 15, Plate 2, were found in a small quantity of the *Assam* limestone which had been brought to *Gowahatti* for the purpose of making lime: all these but 15 have been found in the *Chirra* limestone also.

The insulated situation of the coal measures at *Chirra Punji* affords an excellent opportunity for their examination, owing to the great extent of surface which is free from soil and alluvium, so that the geologist has no obstacle to encounter but the dense vegetation peculiar to the climate.

The great sandstone composing here as elsewhere the base of the coal measures, forms the lofty front of the mountains facing the plains. The lower beds consist of a coarse conglomerate, as already stated, represented at *i,* in the preceding section, resting on greenstone after the manner of similar conglomerates in nearly all countries in which their fundamental rocks have been observed*. When we consider that this is not merely the case with the sandstone of the *Kásya* mountains, but that the whole series of sandstones throughout Central India rest on the flanks of ranges of sienite, greenstone, and basalt, we cannot apply more appropriate language in elucidation of this general feature in our geology, extending as it does over an area of 1800 geographical miles in length, and 300 in breadth, than the following remarks of De la Beche:—" As we can scarcely conceive such general and simultaneous movements in the interior strata immediately preceding the first deposit of the red sandstone series, that every point on which it reposes was convulsed and threw off fragments of rocks at the same moment; we should rather look to certain foci of disturbance for the dispersion of fragments, or the sudden elevation of lines of strata, sometimes perhaps producing ranges of mountains in accordance with the views of M. Elie de Beaumont." Had this idea resulted from observations in India, rather than in Europe, it could not have been more appropriate, or formed so as to convey a more accurate notion of the nature and connexions of our red conglomerates.

Ascending through the series of beds of this rock in the *Kásya* mountains, we find the coarser strata occasionally reappear, succeeded again by the normal beds which are fine, durable, and grey colored.

In some places, but especially when approaching the upper third of the series, the colors become variegated, and ultimately the whole, or nearly so, assume a brick red color. The higher strata form a barren table-land with lengthy sloping summits extending to the distance of ten miles towards the interior of the mountains.

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* Speaking of the porphyry on which the red conglomerates of Devonshire rest, De La Beche observes (Manual Geol. 388).—" When however we extend our observations, we find that our conglomerates are very characteristic of deposits of the same age in other parts of Britain, France, and Germany, and they most frequently though not always rest on disturbed strata."

The limestone and coal about to be described, repose in an elevated position on either side of the adjoining summits; whether the rocks of which these last are composed, occupy a superior geognostic position with regard to the coal or not, is somewhat doubtful; but as far as it is safe to determine from inquiries of a partial nature, we may consider the sandstone from the base of the mountains to the higher peaks along their flanks as an uninterrupted series of beds, and consequently, that the coal is a newer rock than the sandstone composing adjacent summits.

In the sandstone upon which the coal and limestone immediately rest at *Chirra*, a bed of boring shells, figs. 8, 9, 10, plate VII. occur composing a considerable portion of the rock in certain places. The shells were of the size and form of the *Teredo navalis*, but they are mineralized so unfavorably as to render it doubtful to what genus they really belonged*.

It is here worthy of remark that the old red sandstone at the base of the coal measures at *Caithness*, and other parts of Britain contains fishes, none of which appear in the superincumbent beds, while at *Chirra* we have a sandstone bearing the character of the old red, and like it reposing on igneous rocks, and supporting beds of limestone and coal; but instead of fishes abounding in the peculiar boring shells just mentioned, not one of which could be found in the superimposed rock, nor could one of the numerous shells of the latter be found in the subjacent rock, thus indicating both in Europe and India, that a sufficient interval of time had elapsed between the period at which the formation of the conglomerates was finished, and that at which the production of the limestone commenced, to allow of the disappearance from the seas of one class of animals, and the introduction of another. The surface of this great formation for two-thirds of the entire height of the *Kásya* mountains in this situation, is covered with a stratum of marine shells which lie immediately under the soil, and in places these remains are accumulated in extensive deposits of the shingle of an ancient coast represented at *L*, in the preceding figure.

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* In Dr. BUCKLAND's paper on the fossils procured in *Ava* by Mr. CRAWFORD, Geol. Trans. 2nd series, vol. II. p. 387, teredines are mentioned as having been found in blocks of wood in that kingdom and of the same species as those found in London clay. Mr. WISE of *Dacca* has recently found fossil trees in *Camilla*, that remarkable tract of table-land referred to in the first paragraph of the author's report on the physical condition of the *Assam* tea plant. (Transactions of the Agricultural Society of India, vol. IV. p. 1.) Two specimens of these trees have been brought to Calcutta by H. M. Low, Esq., one apparently calcareous, the other is siliceous, yet both were found together in the same place, so that it is to be supposed they were drifted from distinct situations. One of these fossils had been eaten by *termes* and the other perforated by a kind of *teredo*, the holes of which agree in every respect with those formed in recent trees in the *Sunderbunds* by the *teredo navalis;* the trees were dicotyledinous. If they were actually found on the table-land alluded to, the fact will lead to some highly interesting inferences, but whether or not, they serve to form an interesting local link between the fossils of the *Chirra Punji* sandstone, and the living teredo in the Bay of Bengal. Mr. Low has kindly undertaken to procure more information from Mr. WISE regarding the history of the fossil woods in question, which are in the meantime transferred to my friend Dr. CANTOR.

On the summits which intervene between the coal at *Chirra*, and that of *Serarím* above adverted to, the sandstone is chiefly of a brick red color, variegated in places with white. Imbedded in the structure of this rock, the fragment of a fruit or lomentum of a leguminous plant belonging to the tribe mimosea, was found*. This fossil, figs. 4, 5, 6, 7, plate I., like the remains of the teredinous animals already noticed, (though its form is better preserved) is converted into sandstone in no way different from the matrix, except that it was separated from it by a want of cohesion between the form and the impression. It is probable from this condition of the fossil that it may have lived at a time when the rock in which it was imbedded was forming, and been washed into waters and deposited with their sediment. Near it was found a thorny stem, fig. 3, plate I., such as the plant to which the fruit belonged most probably possessed, especially as the thorny species of mimoseæ, producing fruit of such a size, are the most numerous of the tribe. The mimoseæ form a very general feature of the vegetation of the plains, but are rarely if ever seen on mountain summits at such an elevation as the rock in which these fragments were found. The inference consequently tends to support the indications of upheavement afforded by the marine remains so extensively distributed over the acclivities of these mountains, as well as the doctrine of LYELL as to the influence of vicissitudes in physical geography, on the distribution and existence of species. It also leads us to infer, that one feature at least of the existing vegetation of India, has survived those revolutions which have obliterated the existence of tropical forms in the present temperate regions of the earth.

Reposing on the teredinite sandstone near *Chirra*, a detached accumulation of limestone with alternating beds of sandstone, coal, and shale, disposed in horizontal strata, form a precipice about a hundred feet high from the base. Coal, to a thickness of fifteen feet in places occupies a middle position in these strata. A bed of loose, coarse and sharp sand, five feet deep, forms the roof of the coal, and a layer of soft sandstone, about two feet in thickness, rests directly under the soil upon a bed of clay about twenty feet deep. The clay holds an intermediate position between the roof of the coal and the superincumbent sandstone; it is of yellow color, but dark in some places, and intersected horizontally with thin layers of gravel, coal, and an iron pyrites of little value, and in small quantity. From their softness these beds are easily, though not uniformly, acted upon by surface water, which peculiarity may have given rise to that waved appearance observed by Mr. JONES and Captain SAGE in the *Burdwan* and *Palamow* coal fields.

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* We are indebted to the botanical acquirements of my friend and fellow-traveller WILLIAM GRIFFITH, Esq. for a right knowledge of the nature of this fossil.

Following the section from the coal downwards, we meet with an earthy limestone, which, though naturally dark, becomes mealy and whitish on the surface by exposure: it is perhaps the magnesian limestone of the coal measures. This bed is about four feet in thickness, and contains nests of coal, with some traces of shells; a layer of sandstone an inch in thickness divides this from a bed of ordinary compact limestone twenty feet in thickness, containing few if any shells;—an interesting circumstance when compared with the fact of the absence of fossils in limestones of similar character in Central India: a more compact and crystalline bed than the last, abounding in those shells represented in plate 2, then occurs. This is separated from the great sandstone, by a fine calcareous grit stone eight feet in thickness, in which fig. 23, plate VIII. was the only fossil found.

Nummulite limestone (*k*, fig. 1) was first brought to light at the foot of the *Kásya* mountains by Mr. COLEBROOKE in his paper on Mr. SCOTT's notes and specimens, which were forwarded to the Geological Society in 1824*; but the *Chirra Punji* bed of shell limestone here noticed was first observed in 1832 by Mr. CRACROFT†, Mr. SCOTT may have previously found occasional shells in the same rock in the *Kásya* as well as in the *Garrow* mountains‡. It does not however appear that any chronological distinction has been established between the different limestones in this quarter, although the *Chirra* rock is distinguished as a formation from the nummulite limestone, as well by means of its fossils, as by the beds with which it is associated.

The nummulite limestone of *Terriaghát*, where it composes that portion of the *Laour* hills situated at the base of the *Kásya* mountains, is a compact blue rock alternating in single strata with a coarse earthy oolite of a calcareous nature[*]. These appear to rest (as well as could be determined during a cursory examination while passing) on a slate clay composed of argillaceous blue clay with slaty layers of ferruginous matter and sandstone. The compact beds abound in nummulites, and in fragments of the same rock which had been quarried somewhere in this vicinity and conveyed to *Chattak* for the purpose of making lime, a turbinolopsis ocracea was found[†]. Now although we cannot as yet contend for the universal and contemporaneous distribution either of the same organic species or geological formations, yet as the chalk of Europe is represented in several extensive tracts of that continent by rocks which are very unlike, and especially in the *Morea*, by a compact nummulite limestone, and in the South of France by an oolite containing nummulites, there is no reason why, in the present state of our knowledge we should not refer our compact nummulite limestone, together with the oolite associated with it, to the cretaceous group. See Lyell, 4th ed. vol. IV. 287-8, where the observations of MM. Boblaye and Virlet, are referred to in support of the equivalent distribution of chalk and nummulite limestone in Europe.

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* Geological Transactions, vol. I. 2nd series, 132.

† Journal of the Asiatic Society, vol. I. 252.

‡ Geological Transactions, vol. I. 2nd series, 132.

In the *Chirra Punji* coal no vegetable impressions have been found; but slight opportunities have been hitherto afforded of examining the adjoining shales in which they are chiefly to be expected. I found in the bed of coal at *Serarím*, however, which appears to be the same formation, a large phytolithus, or stem, characteristic also of several of the independent coal formations of Europe and America; a similar fossil appears to have been also found by Voysey, in the coal of Central

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[*] Although 40 geographical miles distant from *Silhet*, it is named in Mr. Colebrooke's paper, *Silhet* limestone; but as other limestones may be found nearer *Silhet*, the necessity of being more definite in our allusious to localities in India is obvious. In the following volume of the same Transactions, this rock (supposing it to be the *Silhet* limestone), is said to be white, and also to contain in the *Garrow* mountains vertebræ of a fish; but unless we presume that the Rev. Dr. Buckland, the eminent author of the paper in question, identified these in Mr. Scott's specimens, and that they were overlooked by Messrs. Clift and Webster who examined them for Colebrooke's paper, we must attribute the statement to a similar vague indication of localities as that above referred to; as we look in vain for an instance of Mr. Scott having found vertebræ of fishes in the nummulite limestone, although such were found by him in the sands and clays of the *Caribari* hills, as appears from the list of fossils in Colebrooke's paper.

[†] A madreporite represented by a single star, the radii of which, as well as the form of the fossil, correspond with T. ocracea, represented in the Suppl. vol. Griff. Anim. King.

India* ; thus, the identity of the different beds referred to, is so far confirmed.

With the exception just mentioned, as well as the impressions of lycopodiums and ferns in the shales connected with *Burdwan* coal, organic remains have been hitherto little noticed in Indian coals ; but when we avail ourselves of improved means of observation we find this branch of the subject no less interesting here, than it had been rendered in Europe†.

The microscopic discoveries of the organic tissues of plants recently made by the Rev. Mr. READE in the ashes of English coal, have induced J. W. GRANT, Esq. of Calcutta to repeat those interesting observations with complete success. The ashes of *Serarím* coal, as well as those afforded by several kinds from the neighbourhood of *Silhet*, and one variety of the *Burdwan* coal, display most distinct signs of organic textures ; so much so, that some of the coals of very different localities may be identified by their ashes as having been formed from similar plants under similar circumstances—for instance, one variety of coal from the foot of the hills near *Silhet*, with another from a lofty bed on the summit of the *Kásya* mountains.

With regard to the nature of the rocks in Central India associated with coal, as far as their details have been made out, there can be little question regarding their identity with the coal measures of *Chirra.* FRANKLIN, after an examination of several districts, considered the sandstones of the *Nerbudda* to represent the new red conglomerate of Europe. The Rev. Mr. EVEREST on the other hand, has assigned excellent reasons for supposing those rocks to bear a closer alliance to the old red sandstone, and his views are strengthened, if not confirmed, by more recent and extended observations in a quarter better calculated to afford satisfactory results. The limestone of the same districts were considered by Captain FRANKLIN, and other writers of the same period with no better reason, to represent the lias ; but Mr. EVEREST justly observed, that as no fossils have been found in it, the chances are that it belongs to an earlier date*. Numerous limestones are found so much alike in appearance, that it would be quite impossible to draw a line of distinction between them except by means either of their fossil contents, or their relative position to other rocks whose nature may be better understood; but where, as in the present case, such information is also deficient, we must still hesitate to adopt any decided views regarding them.

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* Res. Phys. Class. Asiat. Soc. 1892.—13.

† A gentleman recently engaged in a survey of one of our coal fields, exhibited a large reed which seemed to be an ordinary species of saccharum, at one of the late scientific soirees at Government House, as the plant from which coal is derived. It is however stated on the authority of LINDLEY and HUTTON, in their Fossil Flora, that no glumaceous plant has been found in a fossil state, though grasses now form a general feature of the vegetation of all countries. Of 260 species of plants discovered in coal formations, 220 are cryptogamous, the remainder afford no instance of any reed, notwithstanding some doubtful appearances to the contrary, and not a single vegetable impression in the coal beds has been identified with any plant now growing on the earth.

It may here be desirable to offer a few observations on the changes of levels which have taken place in our various coal fields. Why one should now occupy the summit of a mountain at an elevation of 4300 feet†, and another remain scarcely emerged above the sea‡, is a question that almost suggests itself in this place; and as the nature of coal has led to the conclusion that it must at least have been formed beneath estuaries, if not at greater depths from the surface§, the causes that have produced its present diversified position cannot fail to excite the deepest interest in our minds. In the course of the inquiry we shall find that there is perhaps no portion of the earth to which the doctrine of existing causes can be applied with more effect in accounting for the physical changes that have taken place, than India.

An inspection of the annexed map Pl. VI. will show the probability of the disturbing forces having been directed in certain lines, one of which extending from A, to B, may be named the secondary volcanic band, from its principal energies appearing to have been exerted during the secondary period. VOYSEY, after a careful examination of several districts in Central India, embraced by this belt observes, "I have had too many proofs of the intrusion of trap rocks in this district" (tablelands west of *Nagpore*) "amongst the gneiss to allow me to doubt of their volcanic origin||." Dr. HARDY, Captains FRANKLIN, JENKINS, and COULTHARD in their several communications to the Asiatic Society, have in certain instances expressed similar views regarding several phenomena presented to their notice in the course of their inquiries in Central India. The appearance of lines here observed in the distribution of trap rocks, was formerly supposed to be irreconcilable to the pro-

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* Gleanings of Science, vol. III. page 207.

† At *Chirra Punji.* ‡ At *Arracan.*

§ Dr. THOMSON considers coal to have been formed by the slow combustion of vegetable matters under great pressure and consequently at considerable depth beneath the surface—vide outlines Mineralogy and Geology 1836 : others refer its origin merely to the accumulation of vegetable matters in estuaries.

|| As. Res. 1829. p. 194.

miscuous nature of volvanic action, and may have tended materially to embarrass the views of geologists in districts not calculated to afford any very striking results.

If we refer to the volcanic belt of the *Molucca* and *Sunda* islands, we shall find evidence of as perfect a lineal tendency in the direction of its active energies as that which the extinct band affords, of having, within the secondary period, extended across the centre of India in a line parallel with the equator from the gulf of *Cambay* to the *Himálaya*.

The active vents of the *Molucca* band have been extended by VON BUCH from *Sumatra* to *Barren Island*, from which point the train may be carried in the same line through the islands of *Narcandam* and *Rambree*, to the coast of *Arracan* and *Chittagong*, as represented on the annexed map; at this situation the two zones intersect each other, so as to form their united focus in the *Kásya* mountains where the energies of both would seem to have been most exerted, the elevatory movements having commenced in the secondary, and continued throughout the tertiary period.

Although oscillations of the surface, and perhaps occasional eruptions may have taken place at all times, attended by the subsidence of one tract, and the upheavement of another, yet the principal energy of the *Vindhya** volcanic belt from A to B, appears as already stated to have been chiefly confined to the secondary period.

A chain of sienite passing on the one hand into granitic rocks, chiefly composed of felspar, and on the other into greenstone and basalt, extends across this portion of the continent. On the flanks of this chain the coal measures repose, rarely forming a series of beds so extensive as observed in England, except perhaps in the *Caribari* hills and along the southern boundary of *Assam*. A sandstone equivalent to the old red, rests immediately on the disturbed strata; with the sandstone, beds of coal and shale, as well as limestone occur: along the flanks of the chain thermal springs are situated, one of these has been recently found by Mr. BETTS in the *Damuda* river near the foot of the *Pachite* hills†. In the *Nerbudda* valley two have also been brought to notice by Dr. SPILSBURY; in *Curruckpore* district several hot springs are mentioned by Mr. JONES, in addition to the well known spring at ***Mongir.*** In ***Assam,*** on the opposite side of the delta they are also common in the same line in several situations along the foot of the *Naga* mountains, thus confirming other indications that have been adduced of the volcanic agency of this extensive band throughout its extent on both sides of the Ganges.

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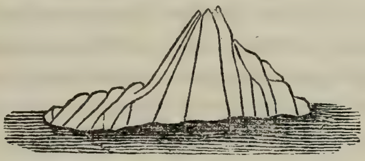
* Such is the geographical name of the range which extends from the *Gulf* of *Cambay* to the Ganges at *Bágalpore*, from which it would seem from certain indications (24.49) to have been extended by a series, obliterated ridges across the *Delta* to the *Garrow* mountains, the leading geological features of the older rocks being, as far as they are as yet determined, the same on both sides (41.)

† Journ. As. Soc. 1832-36.

The other band now to be noticed is a continuation of that which has been described by VON BUCH, as belonging to the volcanic train of the ***Moluccas;*** but it has been extended no farther by him in the direction in which we are now to trace it, than *Barren Island* in 12° 19′ N. lat. in the Bay of Bengal*.

The island of *Narcandam* situated in 13° 22′ N. lat. is a volcanic cone raised to the height of seven or eight hundred feet. The annexed outline, reduced from a sketch made by WILLIAM GRIFFITH, Esq., while passing within half a mile of the shore, shews the figure of the cone; the upper part of which is quite naked, presenting lines such as were doubtlessly formed by lava currents descending from the crater to the base, which last is covered with vegetation. No soundings are to be found at the distance of half a mile from the shore.



The next volcanic islands to be observed, are those which form a small archipelago on the *Arracan* coast. The largest of these is ***Rambree,*** described in the fourth volume of the Asiatic Journal by the late Lieut. FOLEY. It is situated close to the low marshy coast of *Arracan,* and is formed of ranges of mountains extending in the direction of north-northwest, varying in height from five to fifteen hundred feet; one peak named *Jeeka,* is raised to an elevation of 3000 feet above the sea. The plains from which the ridges ascend slope down to the sea with the occasional interruption of low ridges containing basin-like cavities large enough for the cultivation of rice. The highest portions of the plain are composed of shingle, the same as the recent breach, a circumstance which may be observed on removing the soil.

Earthy cones covered merely by a green sward, and situated generally in marshy grounds are ranged along the shores of ***Rambree*** as well as the adjoining islands and coast of ***Arracan:*** their naked appearance, contrasted with the dense marshy forests from which they ascend, is said to have a singular effect, heightened by a few scattered plants of the Tamarix indica, elsewhere found only in sandy deltas and islands along the course of the great rivers, growing on their sides; on the summit of each cone a spring of muddy water is found, through which gas escapes in bubbles, a peculiarity which has procured for them the name of mud volcanoes. These cones, although they excited no interest when first described by Lieut. FOLEY*, are characteristics of the coasts of *Chili* and *Calabria*, and are well known to result from some of the most interesting and awful visitations to which the surface of the earth is exposed. They are of a similar nature, but of much greater size than the cones of earth which formed on the coast of *Chili* during the great earthquake of 1822, where they are referred to fissures produced in the granitic rocks through which water mixed with mud was thrown up†. The alluvial plains of *Calabria* present similar cones of sand, indicating the alternate rising and sinking of the ground.

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* See Plate III. LYELL's Principles Geol. vol. XI. 4th ed.

Sir W. HAMILTON explains such phenomena by supposing the first movement to have raised the fissured plain from below upwards, so that the rivers and stagnant waters in bogs sank down, but when the ground was returned with violence to its former position the mud was thrown up in jets through fissures‡.

Near *Kaeng* in *Rambree*, Lieutenant FOLEY found at the foot of one of these cones, masses resembling clink stone, of green color, very hard and sonorous when struck, and he naturally concluded that they must have been ejected from a volcanic vent.

Two of the largest of the cones are situated on a ridge of sandstone 300 feet in height, about 3 miles from *Kyouk Phyoo*, the capital of the island. From one of them called *Nayadong*, vapour and flame was seen by the inhabitants of *Kyouk Phyoo* to issue to the height of several hundred feet above the summit during the principal shock of the earthquake of the 26th August 1833. The phenomenon may have been occasioned by the concussion of the earthquake bursting open some new fissure from which a transitory stream of inflammable gas, such as that which supplies the celebrated burning fountain of *Chittagong* may have issued.

The island of *Chaduba* adjoining *Rambree* is represented in most old charts as a burning mountain, from which it may be alleged that early surveyors witnessed its eruptions; the higher ridges of neither of these islands have been examined, but the shores of *Chaduba*, like those of

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* They were referred by some merely to the decomposition of iron pyrites.

† LYELL, 2, 232, 4th ed. ‡ LYELL, 2, 278. 4th ed.

Rambree, present numerous earthy cones, with springs of mud and gas on their summits.

Three miles south of *Chaduba*, there is a small cone composed of scoriaceous rocks, raised 200 feet above the sea; soundings at its base display those peculiarities which always characterise volcanic coasts*.

The above facts might alone be sufficient to prove the volcanic nature of the coast of *Arracan*, and to justify our extending the train of active volcanic agency from *Barren Island* to the 20° N. Lat. or within five degrees of the *Kásya* mountains as in the annexed map. But the events which took place on this coast during the great earthquake of the 2nd April 1762, and to which the earthy cones are no doubt referrible, place the question in a less doubtful point of view. Sixty square miles of the *Chittagong* coast, suddenly, and permanently subsided during this earthquake. *Ces-lung-Toom*, one of the *Mug* mountains, entirely disappeared, and another sunk so low that its summit only remained visible†. Four hills are described as having been variously rent asunder, leaving open chasms differing from 30 to 60 feet in width‡. In the plain, the earth opened in several places, throwing up water and mud of a sulphurous smell. At *Bar Charra*, 200 lives were lost on a tract of ground that sunk suddenly, but it is said that at *Arracan* where it was supposed the chief force was displayed§, the effects were as fatal as those of the earthquake which happened about the same period at *Lisbon*. At *Dacca* the waters rose so suddenly as to cast several hundred boats on shore, and on retiring, the wave which is described as terrible, swept numbers of persons away||.

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* This is stated on the authority of Captain LLOYD, Marine Surveyor General, to whom the author is indebted for several other interesting items regarding this coast.

† Phil. Trans. vol. LIII. p. 256.

‡ Other mountains and hills were variously disturbed or destroyed, some partly or entirely thrown down so as to obstruct the course of rivers; others sank 25 and others 40 cubits. A *Toom* hill called *Chatter Puttuah*, is described as having "split by little and little till it became reduced to the level of the plain," and in other cases creeks were closed up by banks of sand rising from their bottom. See Phil. Trans. 1763; upon the whole the history of this earthquake may be supposed to be very incomplete, its effects in one district only of the extensive line of coast in which it happened being imperfectly described.

§ See also observations on the disappearance of various islands on the *Chittagong* coast, which are alluded to in the nautical works of the Arabs in the middle of the 16th century. (Journal As. Soc. 466.)—J. P.

|| As an instance of the readiness with which such visitations are forgotten, I may mention that a well written "Historical and Satistical Account of *Chittagong*" has recently been published by a gentleman many years resident in the province, in which no mention is made of this earthquake, though a Chronological list of 120 rájas is given, and the political history traced to a proportionally early date.

It is an interesting observation connected with this earthquake as with that of 26th August 1833, that although both were peculiarly felt at *Arracan*, as well as toward the hills on the northwest side of Bengal, yet they were comparatively little felt in several intermediate situations. At *Ghirotty* where Col. COOTE and a regiment of Europeans were at the time encamped the earthquake of 1762 is described as most alarming, the waters in the rivers and tanks being thrown up to the height of 6 feet, although at *Chandernagore*, only a few miles distant in a southeast direction, its effects were scarcely perceptible.

The earthquake of 26th August 1833, which was attended with the peculiar eruption already adverted to from one of the volcanoes near *Kyouk Phyoo*, was more severely felt at *Mongir*, where the fort and several houses were injured, than in any intermediate position, which might lead us to suppose that although the volcanic energy of the igneous bands we have pointed out may have become extinct, or at least comparatively dormant as they recede from the seas on either side of India, yet that they are still the peculiar seat of occasional disturbance.

The province of *Cutch* already adverted to as forming the western boundary of the carboniferous zone, lost a considerable portion of its surface, which subsided suddenly during an earthquake in 1819, while at the same time an adjoining tract was raised to a higher position than it had previously occupied*.

Although the surface may seem to have acquired greater stability in recent times in proportion as we proceed inland from the points at which the two volcanic bands are intersected by the seas at *Cutch*, and *Chittagong*, yet as far as we are prepared to judge from unquestionable data, the amount of disturbance which has taken place appears to increase as we proceed from *Cutch* towards the east, and from *Chittagong* towards the north, until we arrive at that situation at which both bands meet and cross each other; and thus by a species of synthesis, we find the common focus of disturbance to be situated in the *Kásya* mountains, about the very position in which we have the most direct and unquestionable proof of concentrated action, the circumstances of the raised beach being sufficient evidence of these mountains having been raised to nearly twice their former height since the commencement of the tertiary period.

It remains for the present uncertain whether so great a change in the physical features of India has been effected by paroxysmal violence, such as occasionally even in our own times has been known to destroy one portion of the land, and to raise up another, or by a slow and gradual perpetuation of elevatory movements. It has been before remarked that a destruction of an elevated tract of land, which probably formed a more or less complete series of ridges extending between *Rajmahl* and the *Garrow* mountains, may have taken place.

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* Lyell, 11. 237, also see Capt. BURNES' repor ton Cutch.—ED.

Considering the geological features of those table-lands and mountain chains which extend from *Rajmahl* to the gulf of *Cambay* on the one side, and from the *Garrow* mountains to the *Himálaya* on the other, it becomes a matter of greater probability that the present breach between *Rajmahl* and the *Garrow* mountains was more or less occupied by hills and table-lands, than that this tract of plain escaped all those vicissitudes to which every other feature of our geography has been subject. If this tract, like every other portion of the band which it contributes to form, once presented elevated lands, they would necessarily have formed the northern coast of that sea which it is evident from the remains of an estuary in the *Caribari* hills, as well as from the littoral remains which are spread over the surface of the *Kásya* mountains, must have occupied the place of the present plains of Bengal.

If we admit this reasoning to be correct, little ingenuity will be required to account in a satisfactory way for some of the most interesting points in our geology. The destruction of the highlands, which it is thus probable once filled the space alluded to, by subsidence during some great paroxysm, when another tract of equal extent may have been elevated; or by means of a succession of earthquakes, to the destructive effects of which the action of a sea on the one side, and of the waters of the two great rivers on the other, would powerfully contribute. The interesting discoveries now in progress in Fort William of the bones of land animals intermingled with those of amphibious reptiles and fragments of mountain limestone, wood, and coal, at a depth of from 370 to 450 feet* beneath this portion of the Gangetic delta, seem to refer to some such destruction of dry land on the northern side of Bengal, as that which has been here supposed to have taken place†.

Should the catastrophe referred to have been sudden, we may easily imagine that a devastating wave would have been occasioned of sufficient extent to account for many of the denuded features presented by the geology of Central, and Southern India. The overthrow of the mammoth, whose gigantic remains have been brought to light in such abundance in Central India by Dr. SPILSBURY, may have been occasioned by the same cause; and should signs of upheavement be found to extend at intervals from the raised beach at *Chirra Punji*, towards *Ava* and the *Chittagong* coast, we may be able to refer the destruction of the various species of mastodon, and other extinct animals whose bones are extensively dispersed throughout *Burma*, to the events which took place at the time of such commotion. When the countries in this direction shall have been farther explored by geologists, we may expect to arrive at more exact conclusions than at present, as to the time these changes took place, and the circumstances of the animal and vegetable kingdoms under which they occurred.

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* I here refer to the experiment of boring for water now carried on in Fort William, in which process the augur, five inches in diameter, brought up nothing but clays, sands, and gravels, until the depth of 350 feet had been attained, when the lower end of a humerus, supposed by Mr. J. Prinsep to resemble that of a hyena, was extracted. Soon after a portion of the rib, a chelonian reptile, with detached fragments of mountain limestone resembling that of the *Kásya* mountains, but much corroded, as well as fragments of wood, coal, &c. The depth now attained is 450 feet, and the work is still going on with spirit.

† Two other fragments of the plastron of a turtle have just been brought up from 450 feet depth.—Ed.

Description of the Plates.

MAP.—PLATE VI.

The geological map of Upper India has been constructed chiefly from the authorities referred to in the text; its utility will probably consist merely in shewing how much remains to be done in researches of this nature. The publications of BUCHANAN, HEYNE, VOYSEY, CRAWFORD, DAVY, and many more recent writers, as BENZA, STIRLING, BABINGTON, PEMBERTON, LOW, and several others, some of whose inquiries are still in progress, will probably, when carefully examined, afford sufficient materials for including the southern portion of the continent in this geological sketch. The want of sufficient information regarding the Great Desert has prevented more being said on the subject than occurs in paras. 142-3; barometrical measurements of its levels, and the navigableness of the *Loony* or Salt River, are objects well deserving the attention of future travellers in this quarter. The delineation of the rocks on this portion of the map has been partly derived from ELPHINSTONE's Journey to *Caubul*, and Lieutenant BOILEAU's recent work on the Desert States, which I have not had an opportunity of acknowledging in the text.

PLATE VII.

Fig. 1. Fragment of a *Phytolithus transversus*, from the coal at *Serarím* in the *Kásya* mountains.

Fig. 2. Apparently the mould of a stem found in the shale adjoining the coal measures at *Chirra Punji.*

Figs. 4, 5, 6, 7. Several views of a fossil which Mr. GRIFFITH thinks is probably the lomentum of a species of mimosa, found imbedded in the red sandstone on the road between *Chirra* and *Serarím.*

Fig. 3. Found with the above fruit, and is probably a portion of the stem of the plant to which the fruit belonged.

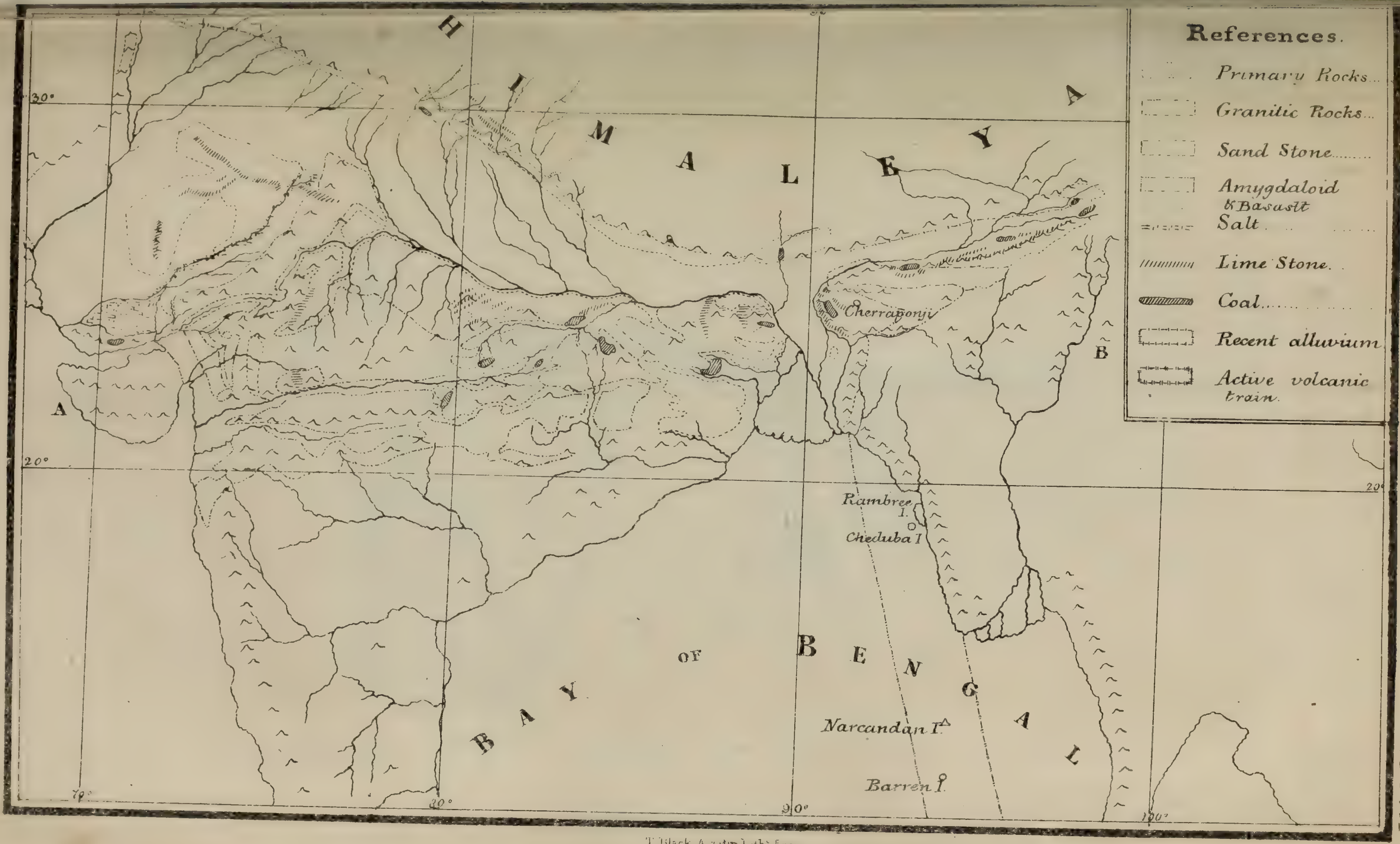
Figs. 8, 9, 10, 11. Teredinites, found in great abundance in the *Chirra Punji* sand-stone, on which the limestone and coal rest.

Fig. 11. From the shale adjoining the coal at *Chirra.*

Fig. 12. Shell from the lower beds of the great sandstone.

PLATE VIII.

Organic remains from the lime-stone which intervenes between the teredinite sandstone and the coal at *Chirra.* The same remains are also



T. Black Asiatic Lithy Pre.

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